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Research note

Physical, Mechanical and Flame Retardant Properties of Particleboard Made from Oil Palm Trunk

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A B S T R A C T

In this study, physical, mechanical and flame retardant properties of oil palm trunk particleboards were evaluated. The properties of oil palm trunk particleboards were compared with polylactic acid (PLA) added board, where PLA was added as a function of natural binder, and PLA added board with calcium sulfate ($CaSO_4$) and magnesium oxide (MgO), where $CaSO_4$ and MgO was added as a function of flame retardant additives. The thickness swelling, modulus of rupture and internal bond strength properties improved as addition of PLA. In comparison to addition of additives, PLA added board with $CaSO_4$ exhibited higher physical and mechanical properties than PLA added boards. The flame retardant properties of PLA added oil palm trunk board with $CaSO_4$ showed higher value of LOI compared to others. Overall results revealed addition PLA improved the physical and mechanical properties of oil palm trunk particleboard and the flame retardant properties increased with addition of additives namely MgO and $CaSO_4$.

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INTRODUCTION

Particleboard is one of the oldest composites to be produced and still remains the world's dominant furniture panel. In Malaysia, the common species used to make particleboard is rubberwood. However, due to deforestation, forest degradation, and increasing wood demand from time to time [1], rubberwood supplies are not enough and there is a need to replace its shortage [2]. Therefore, there are many research work have been done to utilise oil palm trunk (OPT) wastes as raw materials to produce composite based panels such as particleboard in order to reduce OPT wastes which are abundantly available in the oil palm plantation [3]. A study conducted by Hashim, Saari [4] revealed the potential usage of OPT wastes for particleboard manufacturing.

Conventional particleboard incorporated with formaldehyde based resins which have emission of toxic that cause health risk and environmental problems [5, 6]. Therefore, properties of particleboard from non wood resources were enhanced with addition of natural binder such as polylactic acid (PLA). It is biodegradable and bioactive thermoplastic polyester derived from renewable resources. It has been widely used for packaging and textile industries, automotive and engineering applications in the form of biocomposites [7].

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Particleboards have wide range of applications especially used for interior applications in furniture and building industry [8]. However, the flame retardant properties of particleboard made from non wood resources achieve great amount of interest as they are easily subject to thermal decomposition when exposed to flame or high intensity heat source or in other word they have low thermal stability. The thermal stability or flame retardant performance can be improved by treatment of raw material or addition of chemical or additives [9]. The flame retardant will inhibit or delay the ignition and combustion as well as retard the oxidation of board [10]. Thus, in this study two types of flame retardant additives such as calcium sulfate ($CaSO_4$) and magnesium oxide (MgO), which are inorganic flame retardant, were incorporated in oil palm trunk particleboard to enhance flame retardant properties.

MATERIAL AND METHODS

Oil palm trunk particles were obtained from Encore Agricultural Industries Sdn Bhd, Malaysia. Polylactic acid (PLA) used in this study were commercially purchased from Synocell Technology. The fire retardant additives such as calcium sulfate ($CaSO_4$) and magnesium oxide (MgO) were purchased from Bendosen. The PLA, $CaSO_4$ and MgO in the form of powder were added at rates of 10% [11] based on oven dried weight of the particles and manually mixed. Fine particles were manually formed and pre-pressed into

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homogenous single-layer mat using a forming box of dimension 20.5 cm x 20.5 cm at thickness level of 10 mm to manufacture particleboards. The mats were then pressed at a temperature of 180 °C for 20 min with a pressure of 5 MPa and a target density of 0.80 g/cm^3 [11].

For each condition, there were three replicates and total 12 boards were manufactured. Each sample was weighed and its dimensions of 5 cm x 5 cm x 1 cm were measured to determine their target density. The physical and mechanical properties of panels were evaluated by measuring the thickness swelling (TS), modulus of rupture (MOR) and internal bonding strength (IB) according to Japanese Industrial Standard [12]. Modulus of rupture of the panels were determined on samples with dimension of 50 mm x 150 mm by employing Instron Testing System equipped with a load cell having 1000 kg capacity. Samples with dimension of 50 mm x 50 mm were used for IB strength and thickness swelling of the specimen. Flammability of fire retardant board was determined by measuring limiting oxygen index (LOI) according to ASTM D 2863 [13] under control atmosphere with each specimen having 9 replicates.

RESULTS AND DISCUSSION

Physical and mechanical properties of the oil palm particleboards are presented in Figures 1-3. The thickness swelling of the oil palm trunk particleboards improved with addition of PLA content in the boards but decreased as addition of flame retardant additives namely $CaSO_4$ and MgO as shown in Figure 1. Thickness swelling properties of the PLA added board improved of 45.6% in comparison to oil palm board. Moreover, thickness swelling values decreased by 9.1% and 20.5% with addition of flame retardant additives, $CaSO_4$ and MgO respectively, to PLA added board. However, none of the boards met the minimum requirement of JIS standard for Type 8 where swelling in thickness after immersion in water must not exceed 12%. This might be due to the hygroscopic nature of oil palm samples [14].

Both MOR and IB strength values of PLA added board are higher compared to those of oil palm trunk particleboards and additives and PLA added board as illustrated in Figures 2 and 3. There are increases in MOR properties of boards with the addition of PLA and additives at 17.2% for PLA added board, 13.6% for PLA and $CaSO_4$ added board and 10.7% for PLA and MgO added board in comparison to oil palm trunk particleboard. While, values of IB strength of PLA and additives added board increased at 167.7%, 118.6% and 90.3% respectively for PLA added board, PLA and

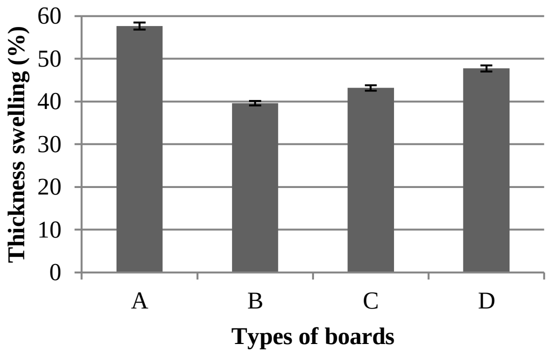

Figure 1: Thickness swelling of oil palm trunk particleboards.
A: Oil palm trunk particleboard
B: Oil palm trunk particleboard with 10% PLA
C: Oil palm trunk particleboard with 10% PLA and 10% $CaSO_4$
D: Oil palm trunk particleboard with 10% PLA and 10% MgO

$CaSO_4$ added board and PLA and MgO added board than control board. It seems that PLA and additives might have developed enhanced bonding of the particles under effect of heat and temperature resulting in better strength characteristics of the samples. Only IB strength characteristics of all samples satisfied the strength requirements for general use of particleboard based on the Japanese Industrial Standard for Type 8 [12].

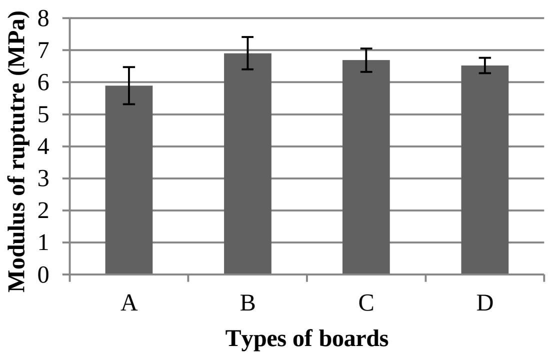

Figure 2: Modulus of rupture of oil palm trunk particleboards.
A: Oil palm trunk particleboard
B: Oil palm trunk particleboard with 10% PLA
C: Oil palm trunk particleboard with 10% PLA and 10% $CaSO_4$
D: Oil palm trunk particleboard with 10% PLA and 10% MgO

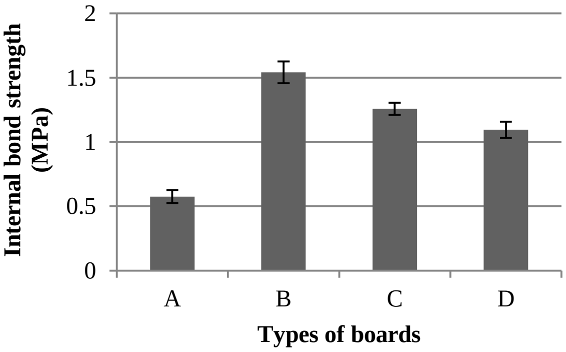

Figure 3: Internal bond strength of oil palm trunk particleboards.
A: Oil palm trunk particleboard
B: Oil palm trunk particleboard with 10% PLA
C: Oil palm trunk particleboard with 10% PLA and 10% $CaSO_4$
D: Oil palm trunk particleboard with 10% PLA and 10% MgO

The greater the amount oxygen required to burnt the samples, the greater the flame resistance of the substance [15]. From Figure 4, PLA and $CaSO_4$ added board showed the highest oxygen index followed by PLA and MgO added board and PLA added board. The flammability of oil palm board improved as addition of PLA and additives with 1.9% for PLA added board, 10.2% for PLA and $CaSO_4$ added board and 4.7% for PLA and MgO added board compared to oil palm trunk board without binder or additives. It showed that the importance of adding additives to improve and enhance the flame retardant properties of oil palm board.

CONCLUSION

In this field of study, influence of polylactic acid as natural binder and $CaSO_4$ and MgO as flame retardant additives on the properties of particleboard made from oil palm trunk was evaluated. The physical, mechanical and flame retardant properties of boards manufactured with the addition of polylactic acid, $CaSO_4$ and MgO were investigated. Overall results showed that polylactic acid can improve physical and mechanical properties of oil palm trunk particleboards but addition of additives such as $CaSO_4$ and MgO are crucial to enhance the flame retardant properties of oil palm board.

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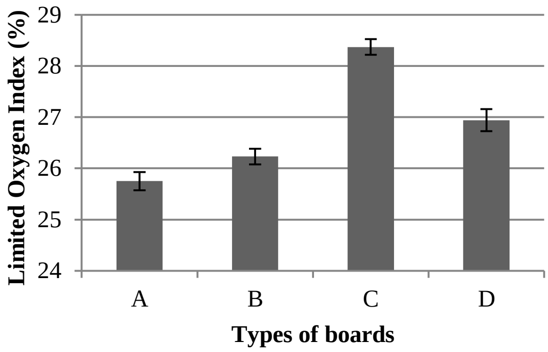

Figure 4: Limited oxygen index of oil palm trunk particleboards.
A: Oil palm trunk particleboard
B: Oil palm trunk particleboard with 10% PLA
C: Oil palm trunk particleboard with 10% PLA and 10% $CaSO_4$
D: Oil palm trunk particleboard with 10% PLA and 10% MgO

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Persian Abstract

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چکیده

در این مطالعه، خواص فیزیکی، مکانیکی و مقاوم در برابر شعله در تخته خرده چوب تنه نخل مورد بررسی قرار گرفت. خواص تخته خرده چوب تنه نخل با مقیاس افزایشی افزوده شده به اسید پلی آلان (PLA) مقایسه شد، در حالیکه PLA به عنوان عملکردی از باندینگ طبیعی اضافه شد و PLA با هیئت مدیره با سولفات کلسیم (CaSO4) و اکسید منیزیم (MgO) افزوده شد، جایی که CaSO4 و MgO به عنوان یک تابع از مواد افزودنی بازدارنده شعله اضافه شد. تورم ضخامت، مدول پارگی و خواص استحکام باند به عنوان افزودنی PLA بهبود یافته است. در مقایسه با افزودنی های افزودنی، PLA هیئت مدیره اضافه شده با CaSO4 دارای خواص فیزیکی و مکانیکی بالاتری نسبت به PLA اضافه شده است. خواص بازدارنده شعله PLA افزودن هیئت مدیره نخل نخل با CaSO4 ارزش بالاتر از LOI را نسبت به دیگران نشان داد. به طور کلی نتایج نشان داد علاوه بر PLA ویژگی های فیزیکی و مکانیکی تخته خرده چوب تنه نخل و خواص بازدارنده شعله با افزودن مواد افزودنی به اضافه MgO و CaSO4 افزایش یافته است.